AD NUMBER

AD485320

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited.

FROM:

**Distribution authorized to U.S. Gov't. agencies and their contractors;
Administrative/Operational Use; FEB 1963. Other requests shall be referred to Defense Supply Agency, Alexandria, VA.**

AUTHORITY

USAMC ltr, 23 Aug 1971

4

MARTIN MARIETTA

485320

MARTIN COMPANY

(9)

SUMMARY REPORT, PERSHING WEAPON SYSTEM, MODIFIED WILD T-2 THEODOLITE LIMITED TEST.

(6)

(15) Contract DA-01-009-ORD-634, DA-01-021-AMC-11436(Z)

(11) February 1963,

(14) OR-3177 Copy

(12) 24 p.

(10) J. T. Alford.

Approved by: E. T. Munnell

E. T. Munnell,
Manager
Systems Test Department

MARTIN COMPANY

ORLANDO
DIVISION
Orlando,
Florida 32805

Refer to:
66-21735

7 March 1966

Defense Supply Agency
Headquarters, Defense Documentation Center
For Scientific and Technical Information
Cameron Station
Alexandria, Virginia 22314

Subject: Contract DA-01-021-AMC-11436(Z)
Release of Report

Reference: a) Letter from Mr. P. C. Noller, AMICOM, to Mr. C. T. Fetrow, M/O, dated February 23, 1966

Enclosure: OR 3177

Gentlemen:

In accordance with the above reference we are forwarding herewith one (1) copy of the following report:

OR 3177 (U) Summary Report Pershing Weapon System Modified Wild T-2 Theodlite Limited Test (U)

Very truly yours,

MARTIN-MARIETTA CORPORATION

C. T. Fetrow
Contracts Manager
PERSHING Program

/gn

cc: AMCPM-PE-ERB, w/o encl.

FOREWORD

Preliminary functional tests and evaluation of two modified Wild T-2 theodolites were conducted during 26, 27 and 28 December, 1962 at McCoy AFB, Florida. The test was conducted by the Local Weapon Systems Test Group of the Martin Company with observers from the Army Mobility Command, Detroit, Michigan. The test was performed under the provisions of PSM-6108.

This report is a summary of the limited test performed using the two modified theodolites with Artillery Set No. 4 and Missile 317.

CONTENTS

Summary v

Introduction vi

I. Equipment Description 1

II. Test Description 9

III. Test Results 12

A. Phase I Checkout and Qualitative Evaluation 12
B. Phase II Accuracy Comparison Test 12

IV. Conclusions 14

V. Recommendations 15

Appendix

Comparative Analysis 16

ILLUSTRATIONS

1	Wild T-2 Theodolites	2
2	Modified Theodolite	3
3	Modified Theodolite Illuminated Plastic Wedge	4
4	Standard Theodolite Centre Point and Read	5
5	Modified Theodolite with Auto-Collimation Adaption	6
6	Optical Plummet Modification	7
7	Inverter Clamp Assembly Modification	8
8	Vertical Azimuth Laying Comparison Testing	10
9	Horizontal Azimuth Laying Comparison Test Setup	11

SUMMARY

An evaluation of the modified Wild T-2 theodolite was accomplished at the helicopter load-secure test site, McCoy AFB, Florida, using Artillery Set No. 4 and Missile 317 in the helicopter mode. The purpose of the evaluation was to determine the compatibility of the modified theodolite with the Pershing Weapon System. The AMICOM manual azimuth laying method was used under simulated tactical countdown conditions with a run being performed through vertical verification and T-zero.

During the three day period numerous test setups and azimuth readings were made. Data recorded with the modified theodolites were compared with data obtained from the Pershing auto-collimating theodolite. Results of this data indicate that accuracy of the modified theodolites is not significantly degraded. Standard deviation values for the differences between readings were found to be 0.0209 ± 0.0034 mils. Image clarity and ease of acquisition were improved.

Although these tests were performed with varied conditions of environments, fog, wind, bright sun and cool temperature, a more complete environmental envelope is requested for further testing. This should include blackout conditions, rain, and G&C window fogging.

From the conclusions of this preliminary test, it was found that the modified theodolite and auto-reflecting operation were compatible with the Pershing Weapon System.

INTRODUCTION

Three Wild T-2 theodolites, each equipped with an auto-collimating eyepiece, are used with the Pershing Weapon System for azimuth laying. Difficulties have been encountered in azimuth alignment techniques of auto-collimating due to poor image return. Therefore, a preliminary functional test and evaluation of two modified Wild T-2 theodolites was conducted, during the week ending 28 December 1962, under the provisions of PSM-6108. The two theodolites used in the test had been modified to provide improved auto-reflecting capabilities which would eliminate the auto-collimating requirement.

The purpose of this functional test was: to determine the compatibility of the modified theodolites with the Pershing azimuth alignment system; to determine the accuracy obtained by auto-reflection; to determine the contrast of the returned image; and to determine the ease of acquisition of the porro-prism.

I. EQUIPMENT DESCRIPTION

The test hardware used during the modified Wild T-2 theodolite evaluation was Artillery Set No. 4, and Pershing Missile No. 317, which are all of basic Group III configuration, and two modified Wild T-2 theodolites. Figure 1 shows one of the modified theodolites as compared to the standard Pershing system theodolites with and without auto-collimating provisions. The modified theodolites included auto-reflecting, visual plumbing, and inverter clamp assembly modifications (Figure 2). In the auto-reflecting modifications, the two theodolites were equipped with an illuminated plastic wedge (Figure 3) in place of the standard centre point and bead (Figure 4) and auto-collimating eyepiece.

Theodolites thus equipped are capable of auto-reflecting and reciprocal collimation (bucking out). The auto-collimating capability of the modified theodolites (Figure 5) was not used during these tests, except for qualitative checkout during Phase I. During Phase II, both auto-collimating and the modified auto-reflecting theodolites were used side by side to compare accuracy data.

The optical plummet feature of the Wild T-2 theodolites was modified to provide a light source for plumbing at night (Figure 6). This light source projects a beam of light from the optical plummet eyepiece to the bench mark on the ground. With this projected light, the theodolite operator can position the theodolite over a pre-surveyed point in total blackout conditions, without the use of other sources of light or additional personnel. The retical of the optical plummet was also modified with quadrant shading to provide more visual contrast.

The third modification was the installation of an inverter clamp assembly (Figure 7). This modification was provided to secure the scale prism in one position, thus preventing inadvertent scale changes.

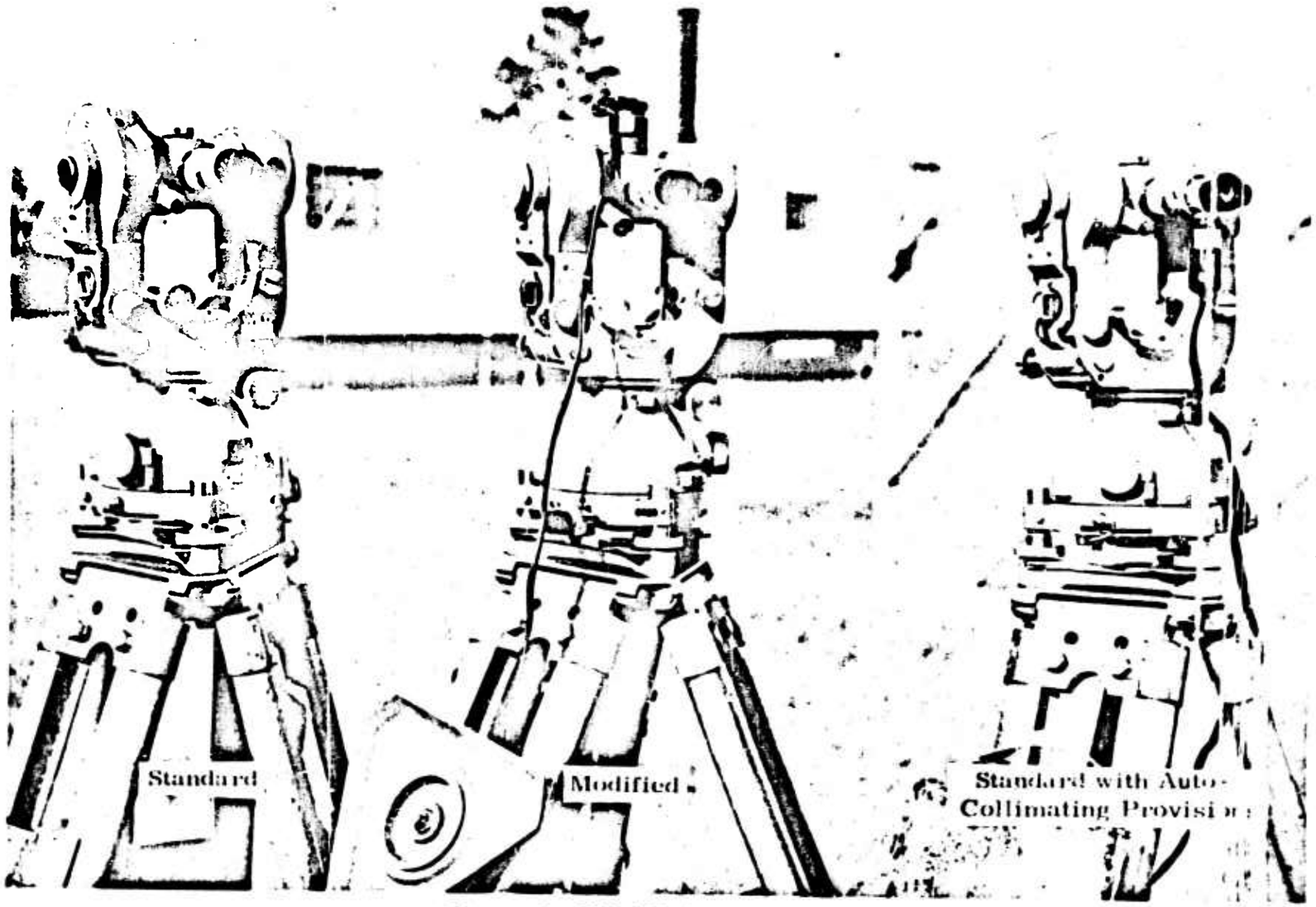


Figure 1. Wild T-2 Theodolites

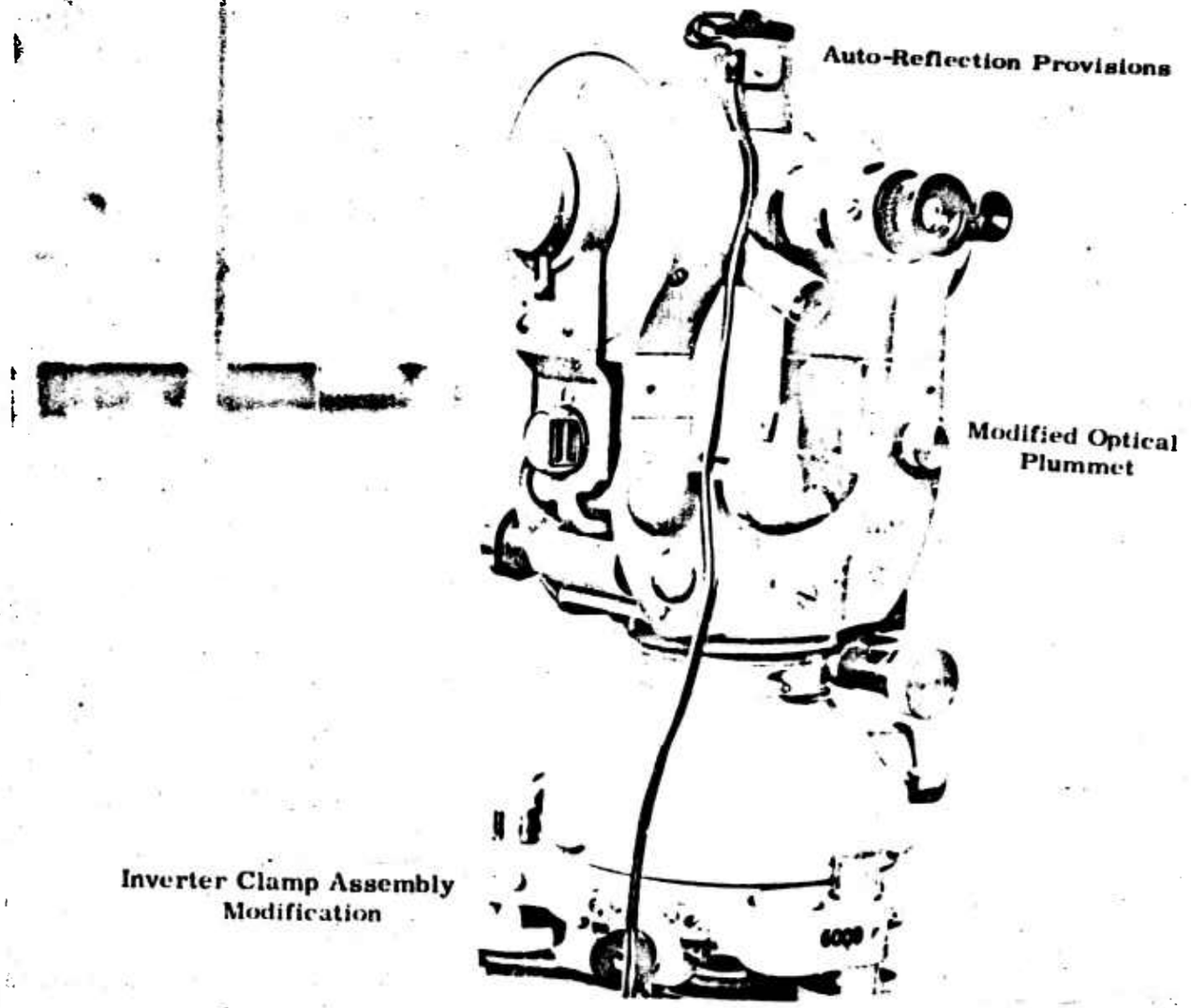


Figure 2. Modified Theodolite

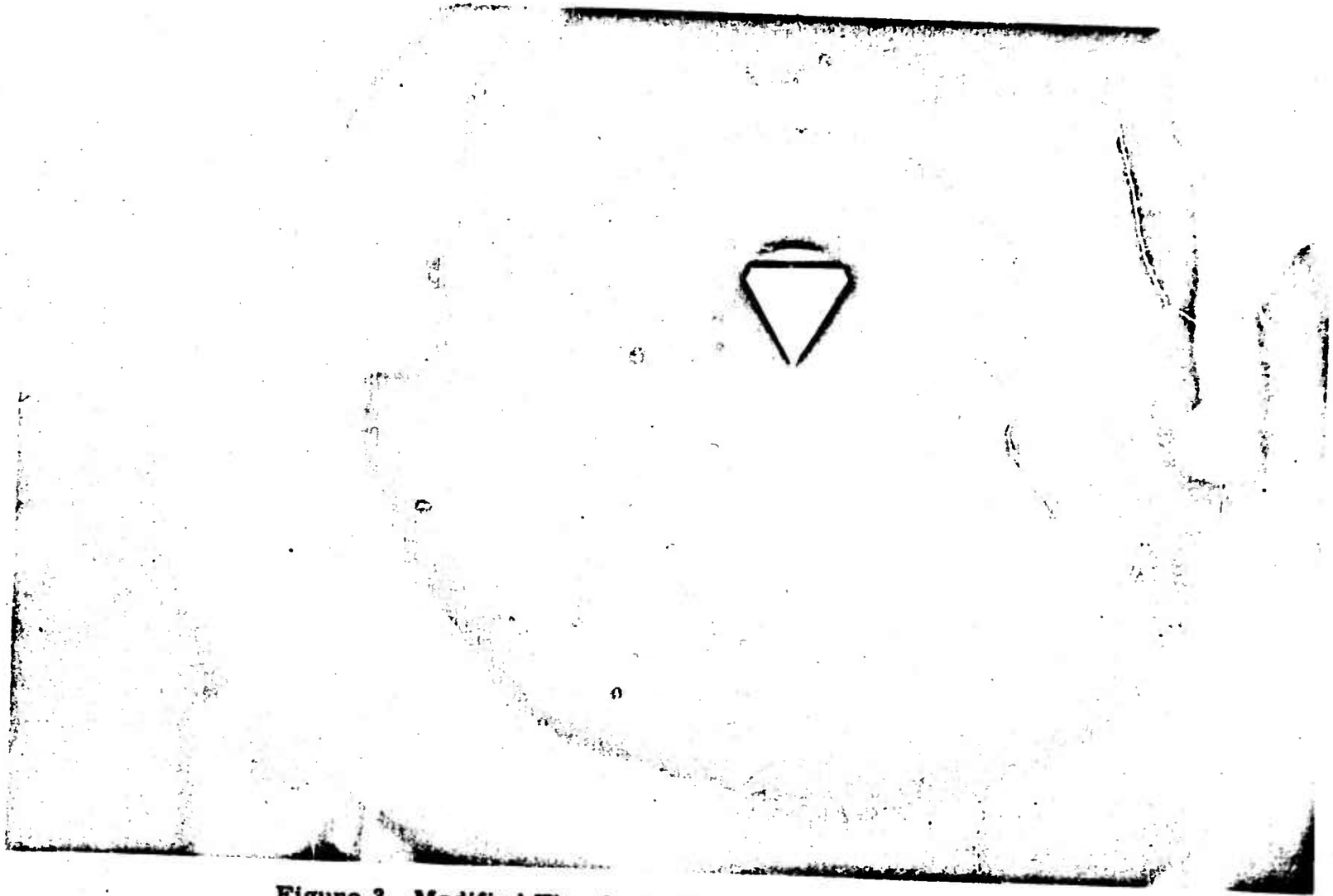


Figure 3. Modified Theodolite Illuminated Plastic Wedge

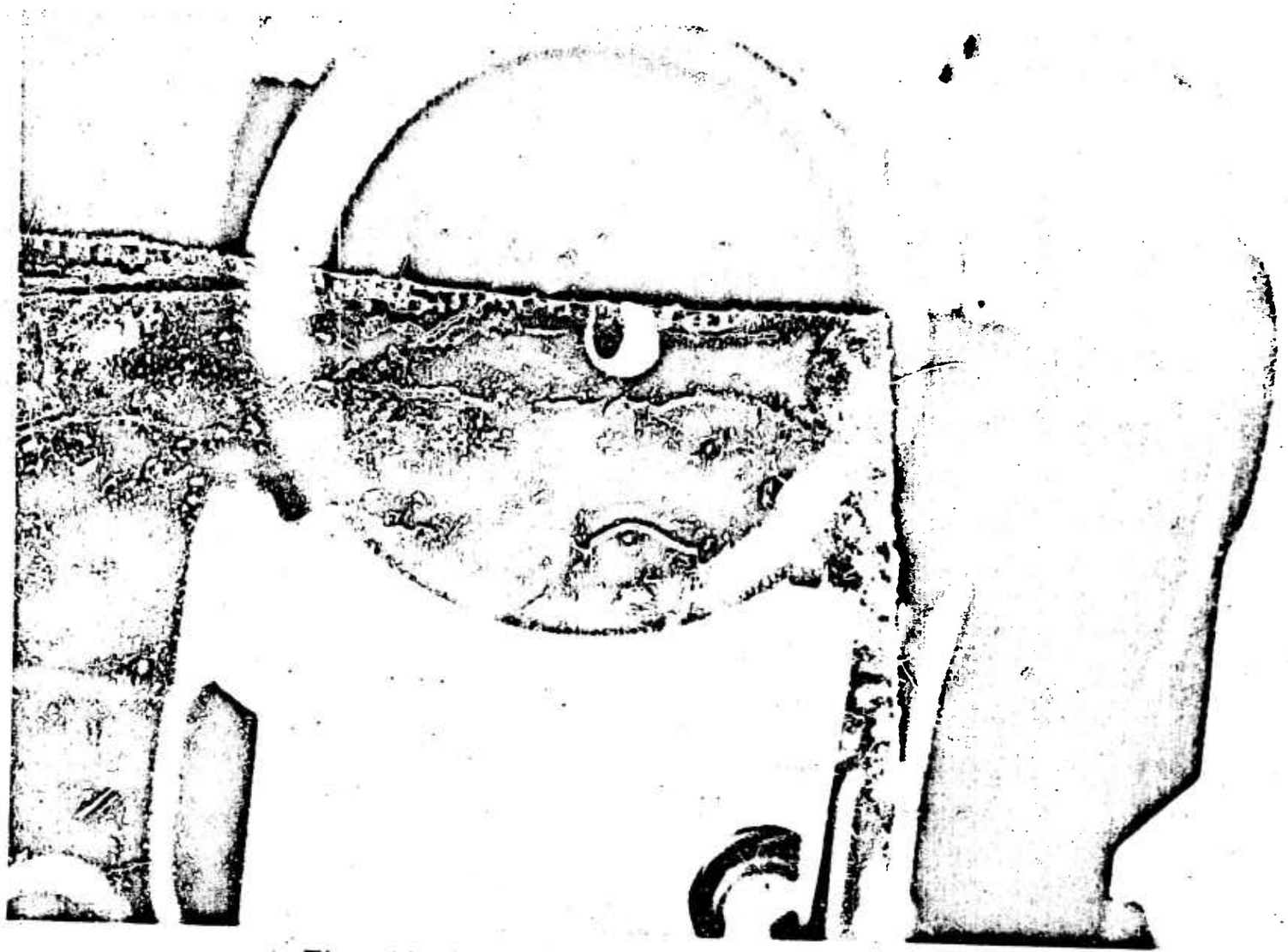


Figure 4. Standard Theodolite Centre Point and Bead

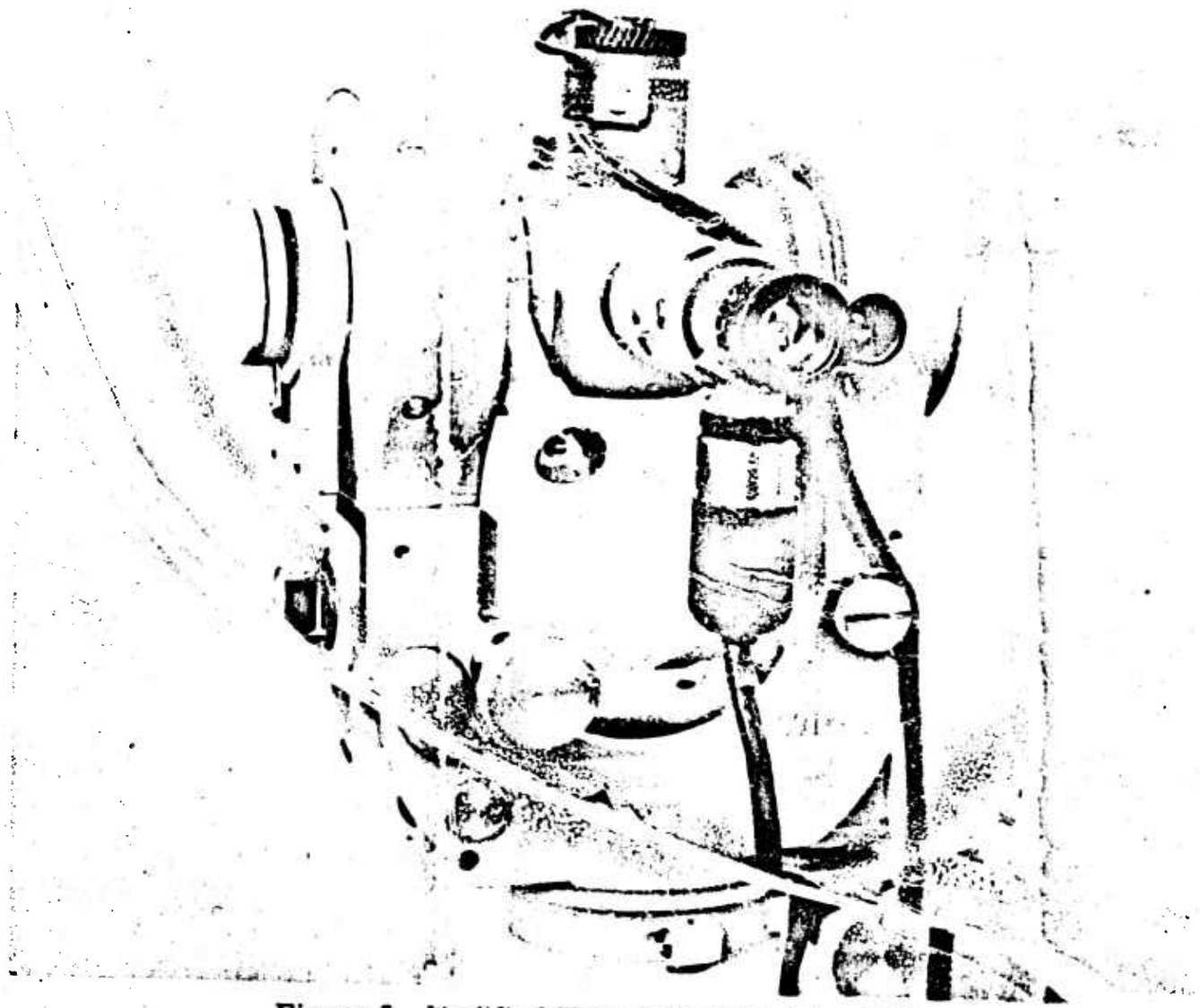


Figure 5. Modified Theodolite with Auto-Collimation Adaptor.

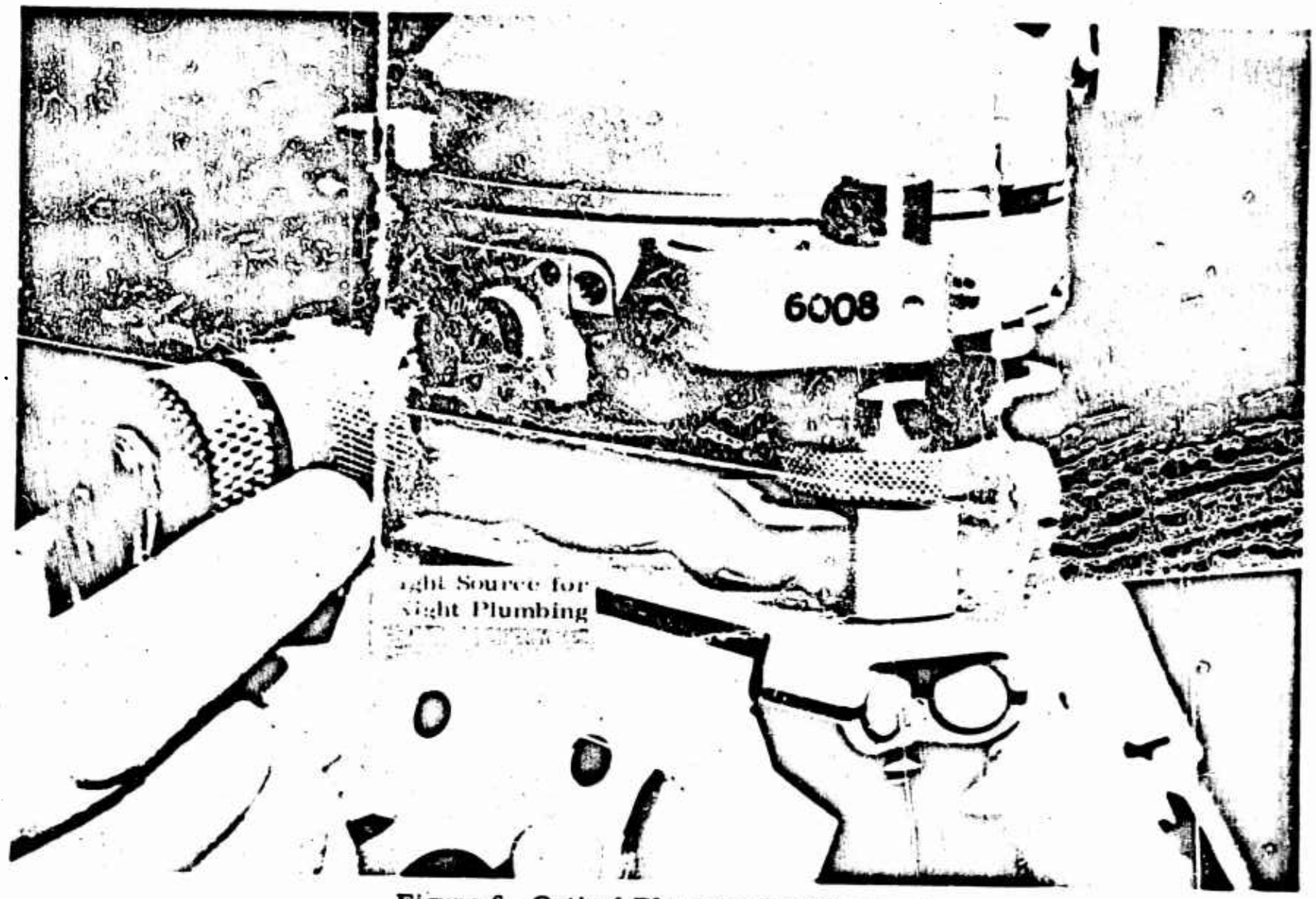


Figure 6. Optical Plummet Modification

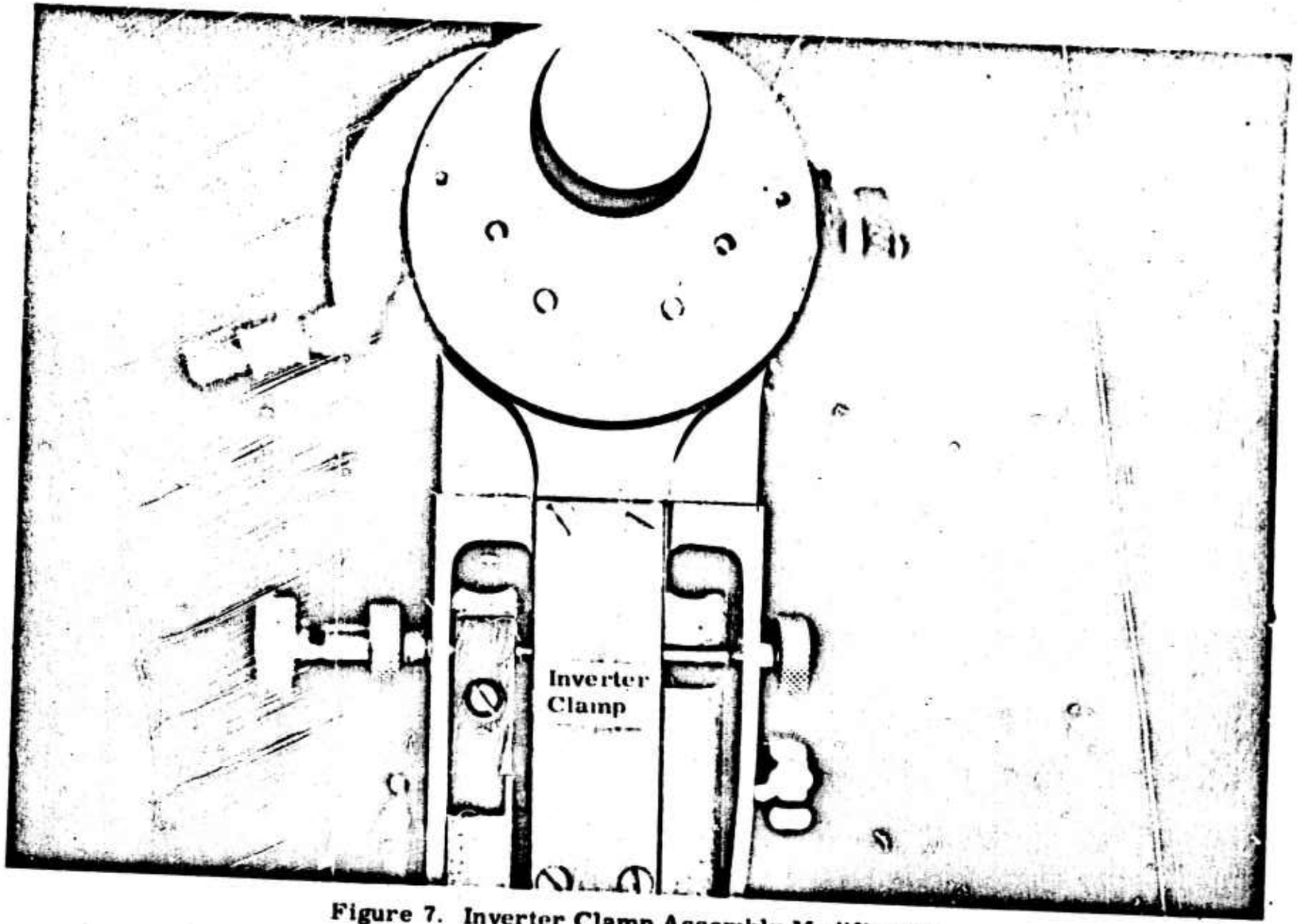


Figure 7. Inverter Clamp Assembly Modification

II. TEST DESCRIPTION

A preliminary evaluation of the modified Wild T-2 theodolites was conducted by the Martin Company on 26, 27 and 28 December, at the helicopter load-secure test site, McCoy AFB, Florida. The limited evaluation was witnessed by a representative of the Army Mobility Command, Detroit, Michigan. The evaluation was performed in two phases.

The first phase was a preliminary checkout and qualitative evaluation using the modified theodolites with auto-collimating eyepieces. During this phase, practice sightings of the missile porro-prism were accomplished. Both auto-collimation and auto-reflection operation with the platform caged and uncaged were checked out. Other azimuth laying operations; during missile countdown, such as reciprocal collimation, were verified to determine buckout techniques. This test phase also served as a familiarization and training period for the test personnel in order for them to become proficient at handling the modified theodolites.

The second phase of operations used a modified theodolite and a Pershing theodolite simultaneously to take azimuth laying readings for comparison purposes. For test operations with the missile in the vertical position, the modified theodolite was positioned approximately 40 feet from the missile, with a Pershing T-2 approximately 20 inches directly behind it (Figure 8). Several readings were first recorded with the ST-120 platform caged and then several were taken with the platform uncaged. The missile was then lowered to the horizontal position with a modified T-2 theodolite positioned approximately 80 inches from the missile and a Pershing T-2 placed approximately 20 inches directly behind the modified T-2 (Figure 9). Readings were then recorded with the missile ST-120 platform uncaged. A missile countdown was performed and both horizontal laying and vertical verification accomplished while using the two modified theodolites.

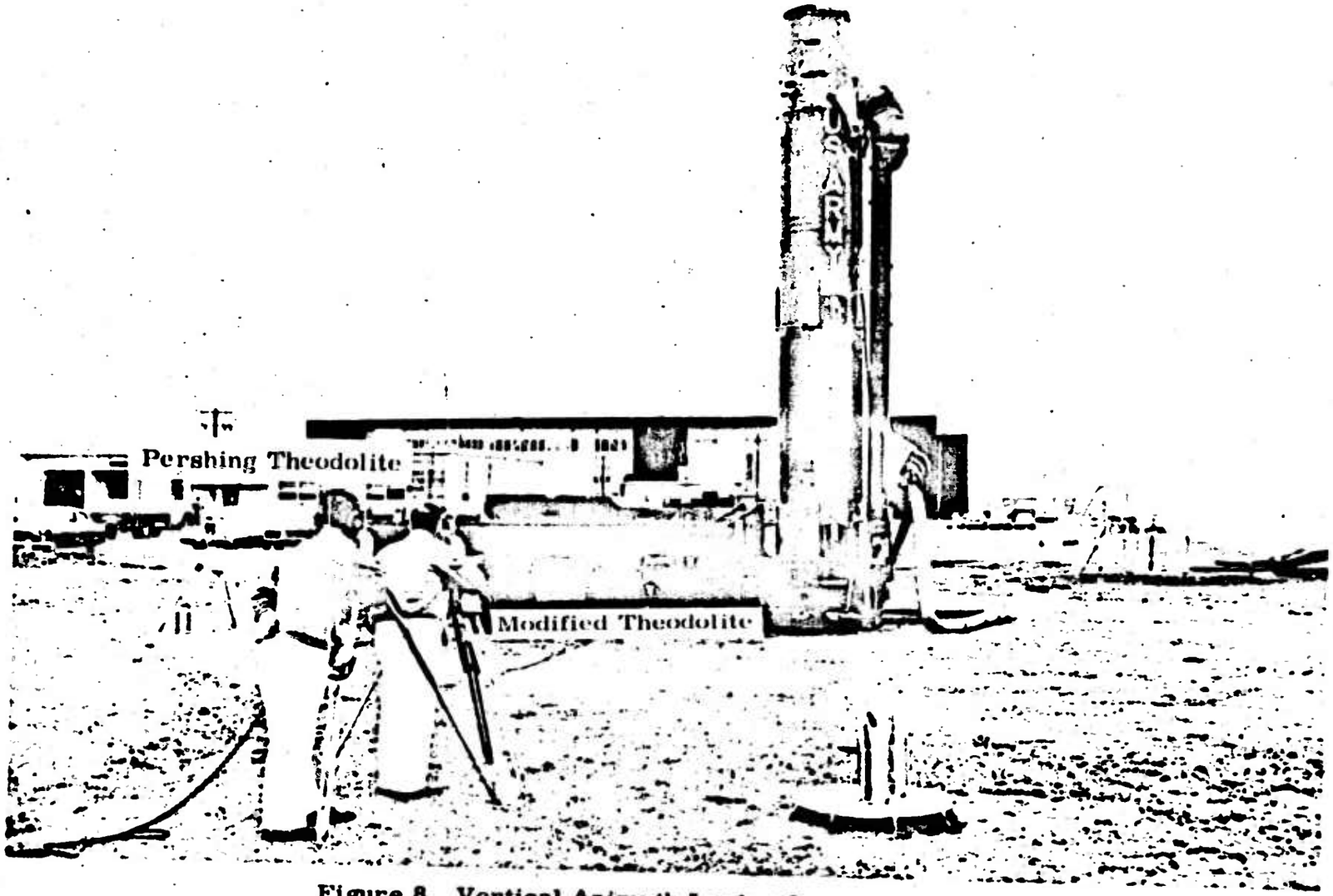


Figure 8. Vertical Azimuth Laying Comparison Testing

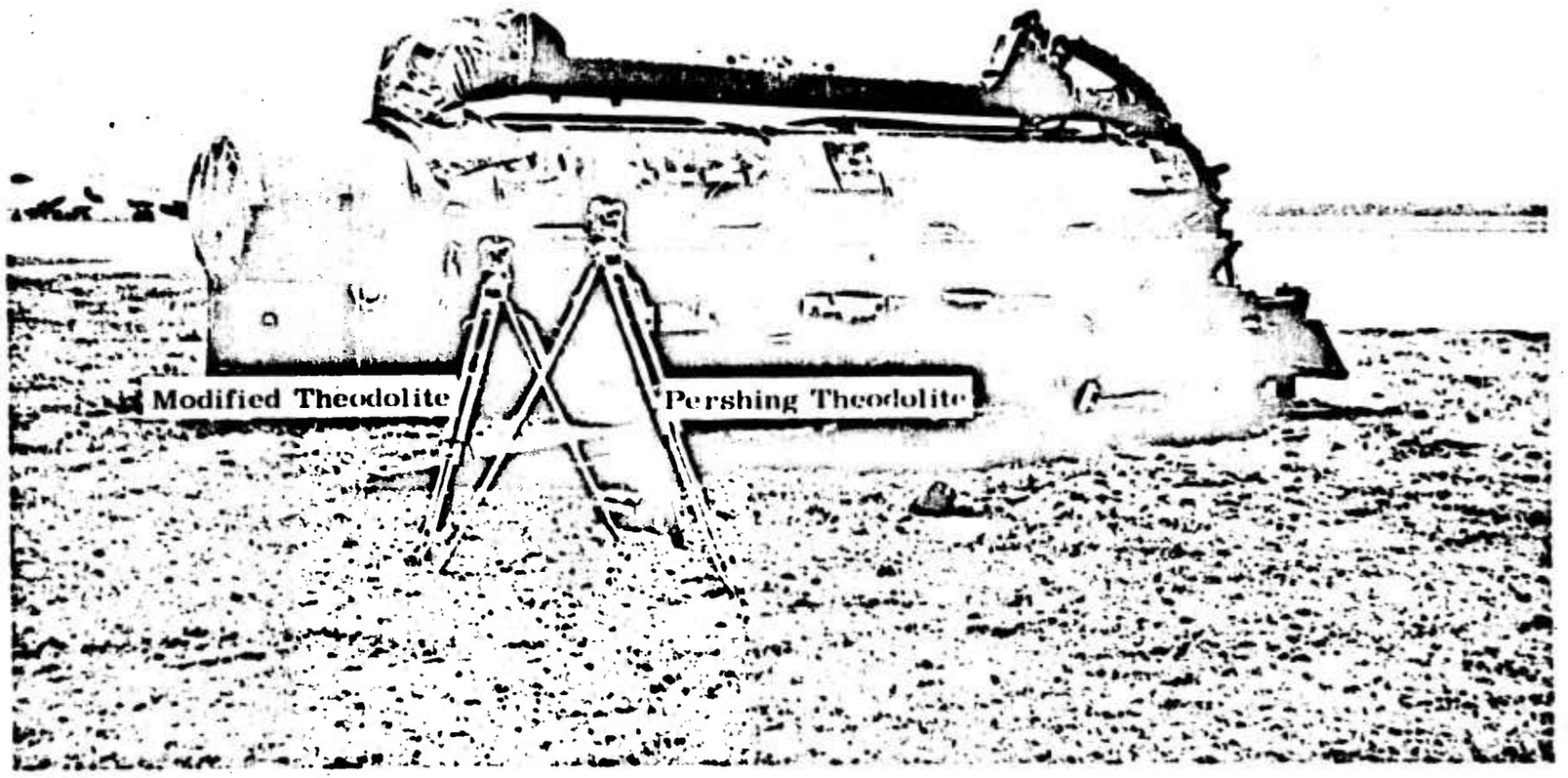


Figure 9. Horizontal Azimuth Laying Comparison Test Setup

III. TEST RESULTS

A. PHASE I-CHECKOUT AND QUALITATIVE EVALUATION

Several sightings were taken on the missile platform prism. These were taken from both the horizontal laying theodolite (HLT) and the vertical laying theodolite (VLT) stations to verify tactical setup conditions. Varied environmental conditions of visibility and ambient light were encountered. These included extremes from dense fog (visibility less than 200 feet) with low light level through clear bright sun light conditions with maximum reflection from concrete paving. Clarity and ease of acquisition was decidedly improved with the illuminated wedge and auto-reflection. Comparisons were made with both types of instruments whenever possible.

Reciprocal collimation, buck-out between two modified theodolites, was also checked out by running a modified triangulation closure exercise. No major changes were required to accomplish the buckout procedure.

B PHASE II - ACCURACY COMPARISON TEST

Simultaneous readings were taken for an accuracy comparison test between the modified Wild T-2 and the Pershing Wild T-2 auto-collimating theodolite. The results of these simultaneous comparison readings are tabulated in Appendix I. For comparison purposes, the Pershing theodolite readings are considered the desired readings and the modified theodolite readings are compared to these desired readings. As there is no absolute value with which to compare these readings, the first modified theodolite reading (in each of the three test setups) is used to determine the theodolite scale correction to initially align the modified theodolite readings with the Pershing theodolite readings. The standard deviation, based upon the limited number of data points available, is calculated to be 2.093 times 10^{-2} mils, with a standard deviation unreliability of $\pm$ 0.349 times 10^{-2} mils. A reading error scatter diagram, frequency distribution and histogram are also presented in Appendix I with the above calculations.

It was found that ease of acquisition was superior with the modified theodolites than with the Pershing theodolites. One tactical countdown was performed using the two modified theodolites in the HLT and VLT locations. Although accuracy cannot be evaluated on the basis of one countdown, it was observed that the countdown time in the azimuth laying portion was improved due to ease of acquisition. No quantitative time measurements were made since they would not have been significant on this countdown.

Ease of acquisition of the illuminated wedge by auto- reflection was especially apparent in bright sunlight and heavy fog, which were two of the conditions experienced during this preliminary test.

In general, auto-reflection is an accurate alignment technique, although not quite as accurate as auto-collimation for short distances. The accuracy of auto-reflection increases as the distance between the theodolite and the reflecting surfaces increases. Although auto-collimation is accurate at all distances, the degree of accuracy depends upon the intensity of the return image.

IV. CONCLUSIONS

From these preliminary tests the following conclusions are indicated:

1. Ease of acquisition of the porro-prism with the modified theodolite is superior to that of the auto-collimating theodolites presently planned for the Pershing Weapon System.

2. The clarity of the auto-reflected illuminated wedge is far superior to that of the auto-collimated return reticle image.

3. Results of the comparison tests with modified theodolites indicate that accuracy repetition was not significantly degraded. From standard deviation computation, one sigma values of 0.029 ± 0.0034 mils (4.2 ± 0.71 sec of arc) were obtained.

4. Both the optical plummet feature and the inverter clamp assembly (scale lock) modifications simplify theodolite operation.

5. The electrical lamp cord with modified theodolites is too short; however, the required length cannot be determined until the lathe bed equipment is available.

The above items indicate that the modified theodolites are compatible with the Pershing Weapon System. If subsequent testing confirms the findings of this preliminary test, the use of modified theodolites would be very advantageous to system operation.

V. RECOMMENDATIONS

As a result of this preliminary test, the following recommendations are offered:

1. Further tests should be performed to verify system compatibility, accuracy, and acquisition.

2. Pending the results of further testing, an auto-collimating eyepiece should be provided for each firing battery equipped with the modified theodolites, for use in calibration, and for possible use in the HLT position.

3. Further testing under blackout conditions, rain, fog, and with the G&C window fogged, should be accomplished for a more thorough evaluation.

4. The modified theodolites should be evaluated during the lathe bed azimuth laying evaluation program.

APPENDIX

COMPARATIVE ANALYSIS

SIMULTANEOUS COMPARISON THEODOLITE READINGS
TEST SETUP NO. 1 (MISSILE IN VERTICAL - PLATFORM CAGED)

Reading No.	Clarity Image	Missile Rotated	Reading (Mils)	Scale Correction	Reading Error
1A	Poor	-	4,800.000		
B	Good	-	4,800.000	0	0
2A	Poor	1 Turn CW	4,800.038		
B	Good	(Az. Ring Hand Crank)	4,800.026	0	-0.012
3A	Poor	2 Turns CW	4,800.518		
B	Good		4,800.533	0	+0.015
4A	-	3 Turns CW	Off prism		
B	Good		4,801.582	0	-
5A	-	1 Turn CCW	Off prism		
B	Good		4,801.480	0	-
6A	Poor	2 Turns CCW	4,800.858		
B	Good		4,800.899	0	+0.041
7A	Poor	3 Turns CCW	4,800.012		
B	Good		4,800.037	0	+0.025
8A	Poor	4 Turns CCW	4,799.137		
B	Good		4,799.104	0	-0.033
9A*	-	1 Turn CW	4,798.526		
B	Good		4,798.540	0	+0.01[illegible]
10A	Poor	1 Turn CW	4,799.452		
B	Good		4,799.470	0	+0.018
11A	Poor	2 Turns CW	4,800.508		
B	Good		4,800.500	0	-0.008

Note: A Readings are Arty 9, Wild T-2 theodolite (Autocollimated).
B Readings are modified Wild T-2 theodolite (Autoreflected).
* Reading 9A was an auto-reflect reading as autocollimation was not accomplished.

TEST SETUP NO. 2 (MISSILE IN HORIZONTAL - PLATFORM UNCAGED)

Reading No.	Clarity Image	Reading (Mils)	Correction Scale	Corrected Reading	Reading Error
12A	Fair	4,799.752		4,799.752	
B	Good	4,799.899	-0.147	4,799.752	0
13A	Fair	4,799.712		4,799.712	
B	Good	4,799.863	-0.147	4,799.716	+0.004
14A	Fair	4,799.690		4,799.690	
B	Good	4,799.830	-0.147	4,799.683	-0.007
15A	Fair	4,799.690		4,799.690	
B	Good	4,799.849	-0.147	4,799.702	+0.012
16A	Fair	4,799.690		4,799.690	
B	Good	4,799.849	-0.147	4,799.702	+0.012
17A	Fair	4,799.636		4,799.636	
B	Good	4,799.762	-0.147	4,799.615	-0.021

Note: Approximately 2 minutes lapse time between readings.
Reading differences due to platform drift.

TEST SETUP No. 3 (MISSILE IN VERTICAL - PLATFORM UNCAGED)

Reading No.	Clarity Image	Reading (Mils)	Correction Scale	Corrected Reading	Reading Error
18A	Poor	4,800.035		4,800.035	
B	Good	4,800.149	-0.114	4,800.035	0
19A	Poor	4,800.039		4,800.039	
B	Good	4,800.105	-0.114	4,799.991	-0.048
20A	Poor	4,800.034		4,800.034	
B	Good	4,800.125	-0.114	4,800.011	-0.023
21A	Poor	4,800.024		4,800.024	
B	Good	4,800.125	-0.114	4,800.011	-0.013

Notes:

1. Approximately 2 minutes lapse time between readings. Reading differences due to platform drift.
2. Cloudy; no sun, cool.
3. Missile not rotated.
4. A readings are Arty 9, Wild T-2 theodolite (Autocollimated).
   B readings are modified Wild T-2 theodolite (Autoreflected).

STANDARD DEVIATION COMPUTATION

$$S = \sqrt{\frac{\Sigma_1^n = 1 (X_i - \bar{X})^2}{n}}$$

where:

S = Standard Deviation

Xi = Reading Error

$\bar{X} = \frac{\Sigma X_i}{n}$

n = Number of Readings Used.

Reading No.	Xi	$\bar{X}$	Xi-$\bar{X}$	$(Xi-\bar{X})^2$
1	0	-0.0016	+0.0016	0.026×10^{-4}
2	-0.012	-0.0016	-0.0104	1.08×10^{-4}
3	+0.015	-0.0016	+0.0166	2.72×10^{-4}
4	-	-	-	-
5	-	-	-	-
6	+0.041	-0.0016	+0.0426	18.15×10^{-4}
7	+0.025	-0.0016	+0.0266	7.07×10^{-4}
8	-0.033	-0.0016	-0.0314	10.00×10^{-4}
9	-	-	-	-
10	+0.018	0.0016	+0.0196	3.85×10^{-4}
11	-0.008	0.0016	-0.0064	0.41×10^{-4}
12	0	0.0016	+0.0016	0.026×10^{-4}
13	+0.004	0.0016	+0.0056	0.314×10^{-4}
14	-0.007	0.0016	-0.0054	0.292×10^{-4}
15	+0.012	0.0016	+0.0136	1.85×10^{-4}
16	+0.012	0.0016	+0.0136	1.85×10^{-4}
17	-0.021	-0.0016	-0.0194	3.76×10^{-4}
18	0	-0.0016	+0.0016	0.026×10^{-4}
19	-0.048	-0.0016	-0.0464	21.55×10^{-4}
20	-0.023	-0.0016	-0.0214	4.58×10^{-4}
21	-0.013	-0.0016	-0.0114	1.30×10^{-4}
	$\Sigma Xi = -0.028$			$\Sigma(Xi-\bar{X})^2 = 78.856 \times 10^{-4}$

$$\bar{X} = \frac{\Sigma Xi}{n} = \frac{-0.028}{18} = -0.0016$$

$$S = \sqrt{\frac{\sum_{1}^{n} (Xi - \bar{X})^2}{n}} = \sqrt{\frac{78.856 \times 10^{-4}}{18}} = 2.093 \times 10^{-2} \text{ mils}$$

$$S_{unrel} = \frac{S \text{ sample}}{\sqrt{2n}}$$

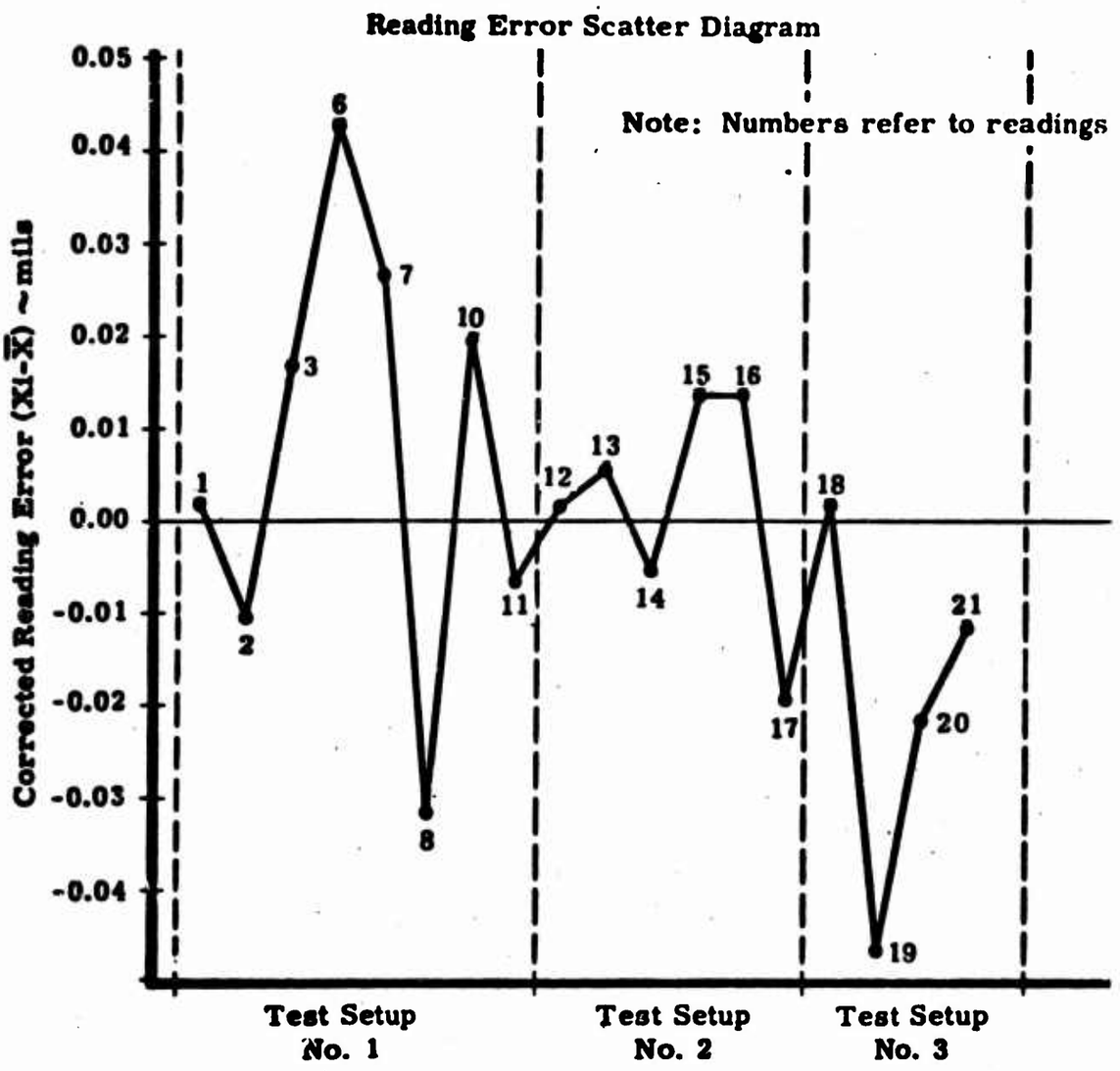
where:

S_{unrel} = Standard Deviation Unreliability

S sample = Standard Deviation

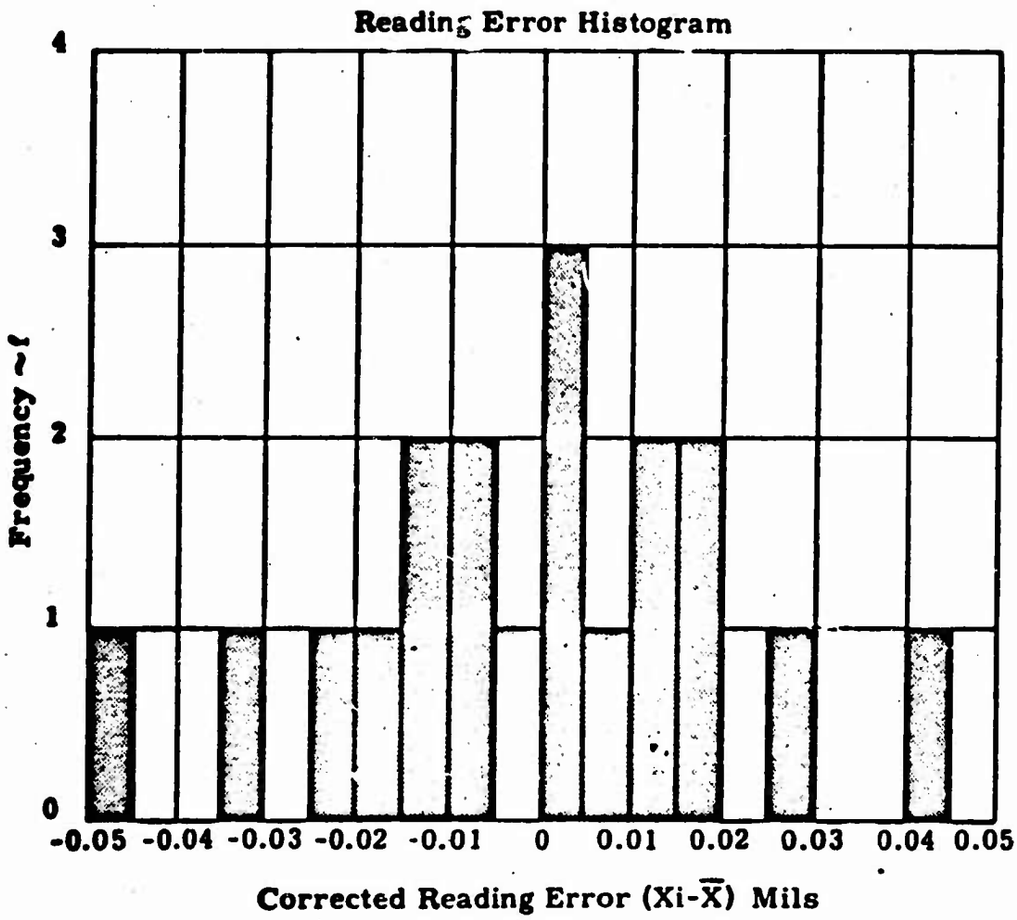
n = Number of Readings Used

$$S_{unrel} = \frac{2.093 \times 10^{-2}}{\sqrt{2\,(18)}} = 0.349 \times 10^{-2} \text{ mils}$$



Frequency Distribution of Reading Error

Reading Error Limits	Frequency f	Reading Error Limits	Frequency f
0 to 0.005	3	0 to -0.005	0
0.005 to 0.010	1	-0.005 to -0.010	2
0.010 to 0.015	2	-0.010 to -0.015	2
0.015 to 0.020	2	-0.015 to -0.020	1
0.020 to 0.025	0	-0.020 to -0.025	1
0.025 to 0.030	1	-0.025 to -0.030	0
0.035 to 0.040	0	-0.030 to -0.035	1
0.040 to 0.045	0	-0.035 to -0.040	0
0.045 to 0.050	1	-0.040 to -0.045	0
		-0.045 to -0.050	1


Reading Error Histogram
Frequency ~f
0
1
2
3
4
-0.05
-0.04
-0.03
-0.02
-0.01
0
0.01
0.02
0.03
0.04
0.05
Corrected Reading Error (Xi-$\overline{X}$) Mils

Prepared by: J. R. Alford

J. R. Alford
Systems Test Department

OR 3177 Martin Company, Orlando Division SUMMARY REPORT PERSHING WEAPON SYSTEM MODIFIED WILD T-2 THEODOLITE LIMITED TEST March 1963 Contract No. DA-01-009-ORD-634 30p. UNCLASSIFIED REPORT This report contains the results of a test program making use of a modified T-2 theodolite and performed during the Helicopter Load-Secure testing. It concludes that the modified theodolite is more suitable than the present theodolite but more testing should be done.	UNCLASSIFIED 1. Guided Missiles (Surface-to-Surface) - Testing 2. Pershing - Theodolite I. Contract DA-01-009-ORD-634	OR 3177 Martin Company, Orlando Division SUMMARY REPORT PERSHING WEAPON SYSTEM MODIFIED WILD T-2 THEODOLITE LIMITEL TEST March 1963 Contract No. DA-01-009-ORD-634 30p. UNCLASSIFIED REPORT This report contains the results of a test program making use of a modified T-2 theodolite and performed during the Helicopter Load-Secure testing. It concludes that the modified theodolite is more suitable than the present theodolite but more testing should be done.	UNCLASSIFIED 1. Guided Missiles (Surface-to-Surface) - Testing 2. Pershing - Theodolite I. Contract DA-01-009-ORD-634
OR 3177 Martin Company, Orlando Division SUMMARY REPORT PERSHING WEAPON SYSTEM MODIFIED WILD T-2 THEODOLITE LIMITED TEST March 1963 Contract No. DA-01-009-ORD-634 30p. UNCLASSIFIED REPORT This report contains the results of a test program making use of a modified T-2 theodolite and performed during the Helicopter Load-Secure testing. It concludes that the modified theodolite is more suitable than the present theodolite but more testing should be done.	UNCLASSIFIED 1. Guided Missiles (Surface-to-Surface) - Testing 2. Pershing - Theodolite I. Contract DA-01-009-ORD-634	OR 3177 Martin Company, Orlando Division SUMMARY REPORT PERSHING WEAPON SYSTEM MODIFIED WILD T-2 THEODOLITE LIMITED TEST March 1963 Contract No. DA-01-009-ORD-634 30p. UNCLASSIFIED REPORT This report contains the results of a test program making use of a modified T-2 theodolite and performed during the Helicopter Load-Secure testing. It concludes that the modified theodolite is more suitable than the present theodolite but more testing should be done.	UNCLASSIFIED 1. Guided Missiles (Surface-to-Surface) - Testing 2. Pershing - Theodolite I. Contract DA-01-009-ORD-634

OR 3177 Martin Company, Orlando Division SUMMARY REPORT PERSHING WEAPON SYSTEM MODIFIED WILD T-2 THEODOLITE LIMITED TEST March 1963 Contract No. DA-01-009-ORD-634 30p. UNCLASSIFIED REPORT This report contains the results of a test program making use of a modified T-2 theodolite and performed during the Helicopter Load-Secure testing. It concludes that the modified theodolite is more suitable than the present theodolite but more testing should be done.	UNCLASSIFIED 1. Guided Missiles (Surface-to-Surface) – Testing 2. Pershing – Theodolite I. Contract DA-01-009-ORD-634	OR 3177 Martin Company, Orlando Division SUMMARY REPORT PERSHING WEAPON SYSTEM MODIFIED WILD T-2 THEODOLITE LIMITED TEST March 1963 Contract No. DA-01-009-ORD-634 30p. UNCLASSIFIED REPORT This report contains the results of a test program making use of a modified T-2 theodolite and performed during the Helicopter Load-Secure testing. It concludes that the modified theodolite is more suitable than the present theodolite but more testing should be done.	UNCLASSIFIED 1. Guided Missiles (Surface-to-Surface) – Testing 2. Pershing – Theodolite I. Contract DA-01-009-ORD-634
OR 3177 Martin Company, Orlando Division SUMMARY REPORT PERSHING WEAPON SYSTEM MODIFIED WILD T-2 THEODOLITE LIMITED TEST March 1963 Contract No. DA-01-009-ORD-634 30p. UNCLASSIFIED REPORT This report contains the results of a test program making use of a modified T-2 theodolite and performed during the Helicopter Load-Secure testing. It concludes that the modified theodolite is more suitable than the present theodolite but more testing should be done.	UNCLASSIFIED 1. Guided Missiles (Surface-to-Surface) – Testing 2. Pershing – Theodolite I. Contract DA-01-009-ORD-634	OR 3177 Martin Company, Orlando Division SUMMARY REPORT PERSHING WEAPON SYSTEM MODIFIED WILD T-2 THEODOLITE LIMITED TEST March 1963 Contract No. DA-01-009-ORD-634 30p. UNCLASSIFIED REPORT This report contains the results of a test program making use of a modified T-2 theodolite and performed during the Helicopter Load-Secure testing. It concludes that the modified theodolite is more suitable than the present theodolite but more testing should be done.	UNCLASSIFIED 1. Guided Missiles (Surface-to-Surface) – Testing 2. Pershing – Theodolite I. Contract DA-01-009-ORD-634